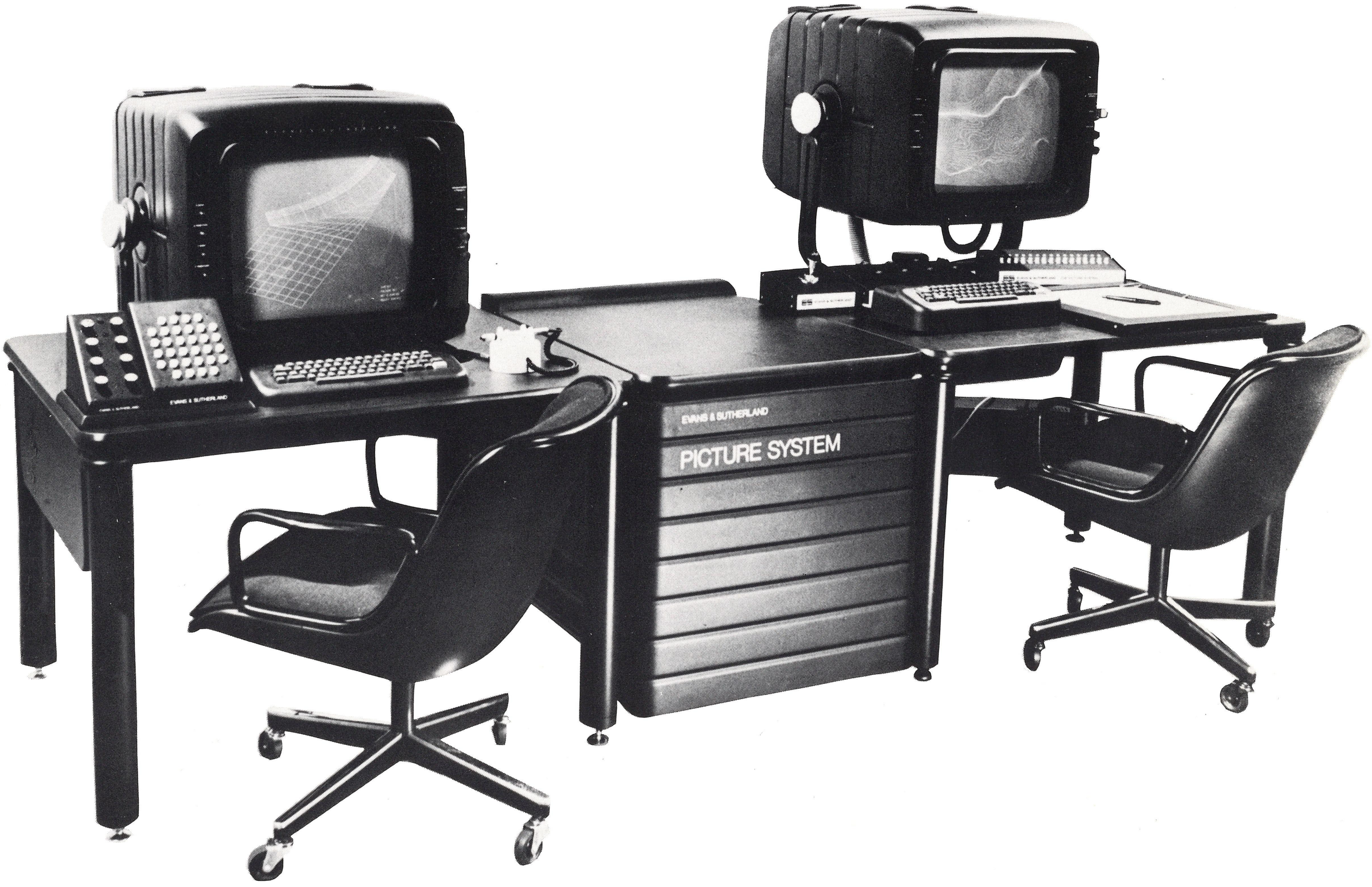
EVANS & SUTHERLAND

MULTI PICTURE SYSTEM

The Multi Picture System is the cost-effective solution for multiple terminal installations requiring high-performance 2-D and 3-D graphics capabilities. Each Picture Station provides real-time user interaction with a 3-Dimensional model displayed with state-of-the-art image quality.

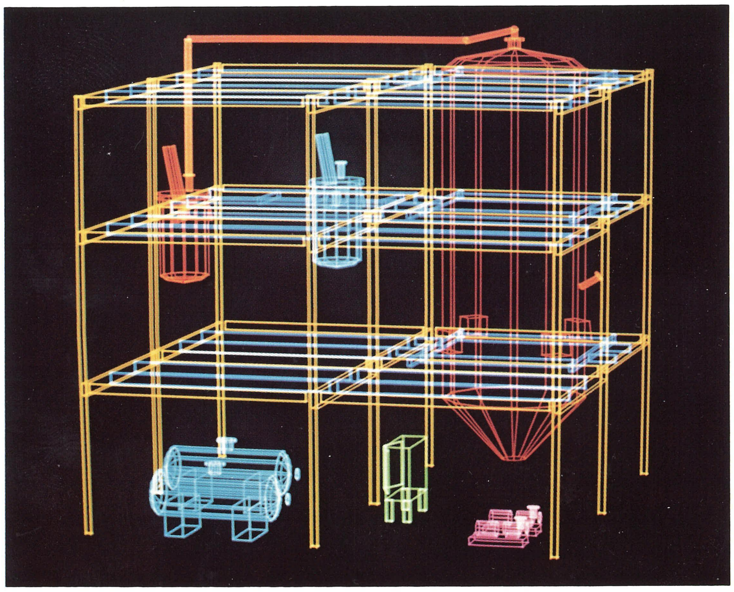
Proven hardware, powerful software, thorough diagnostics, and excellent maintenance make the Multi Picture System the right tool for your computer graphics needs.

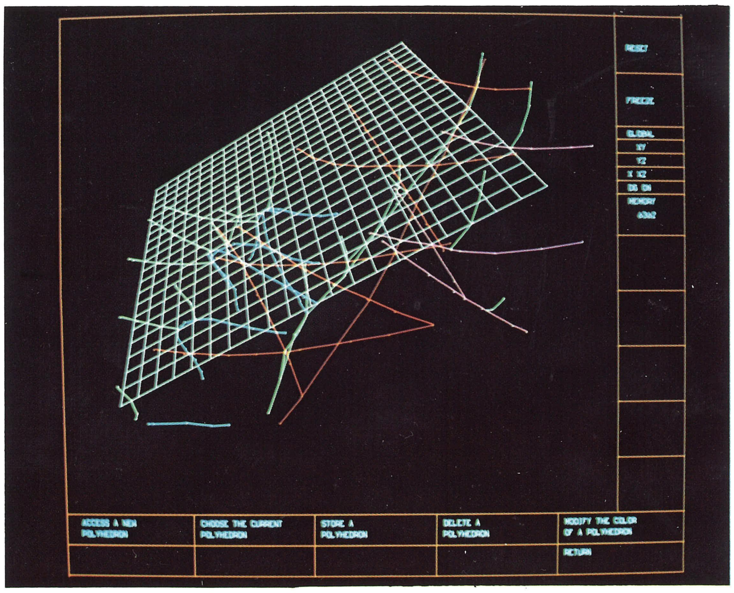


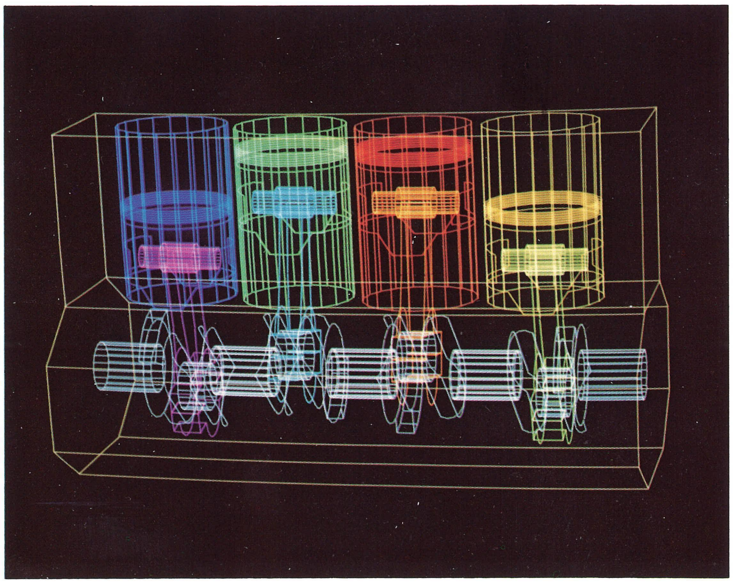
E&S COLOR DISPLAY

Dynamic motion, line drawing computer graphics, and full, rich, bright color—this combination has not been available anywhere before. Evans & Sutherland has overcome the color barrier with the latest addition to the Picture System product line.

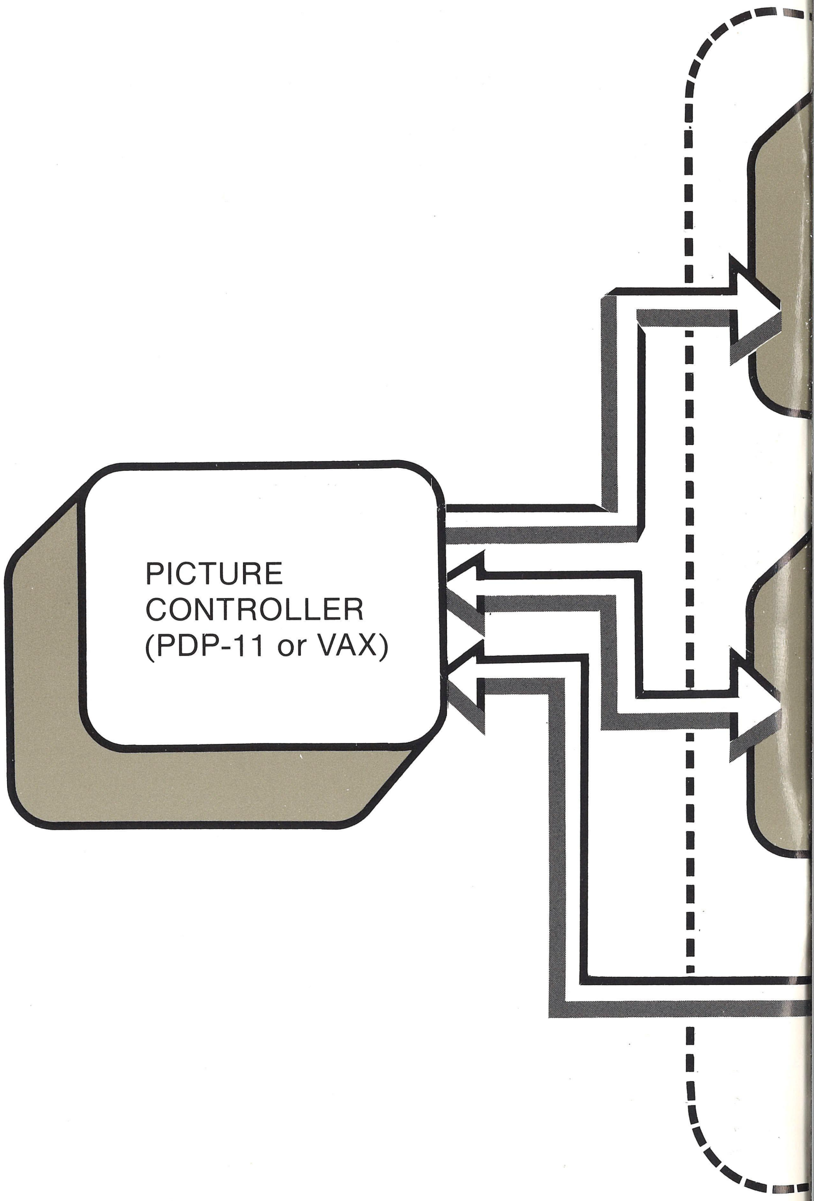
No moving parts, no high voltage switching, no special optics or glasses, no ''buts,'' just full beautiful color generated on our CRT, and backed by the full power of the Multi Picture System's 3-D computer graphics.







SYSTEM ARCHITECTURE

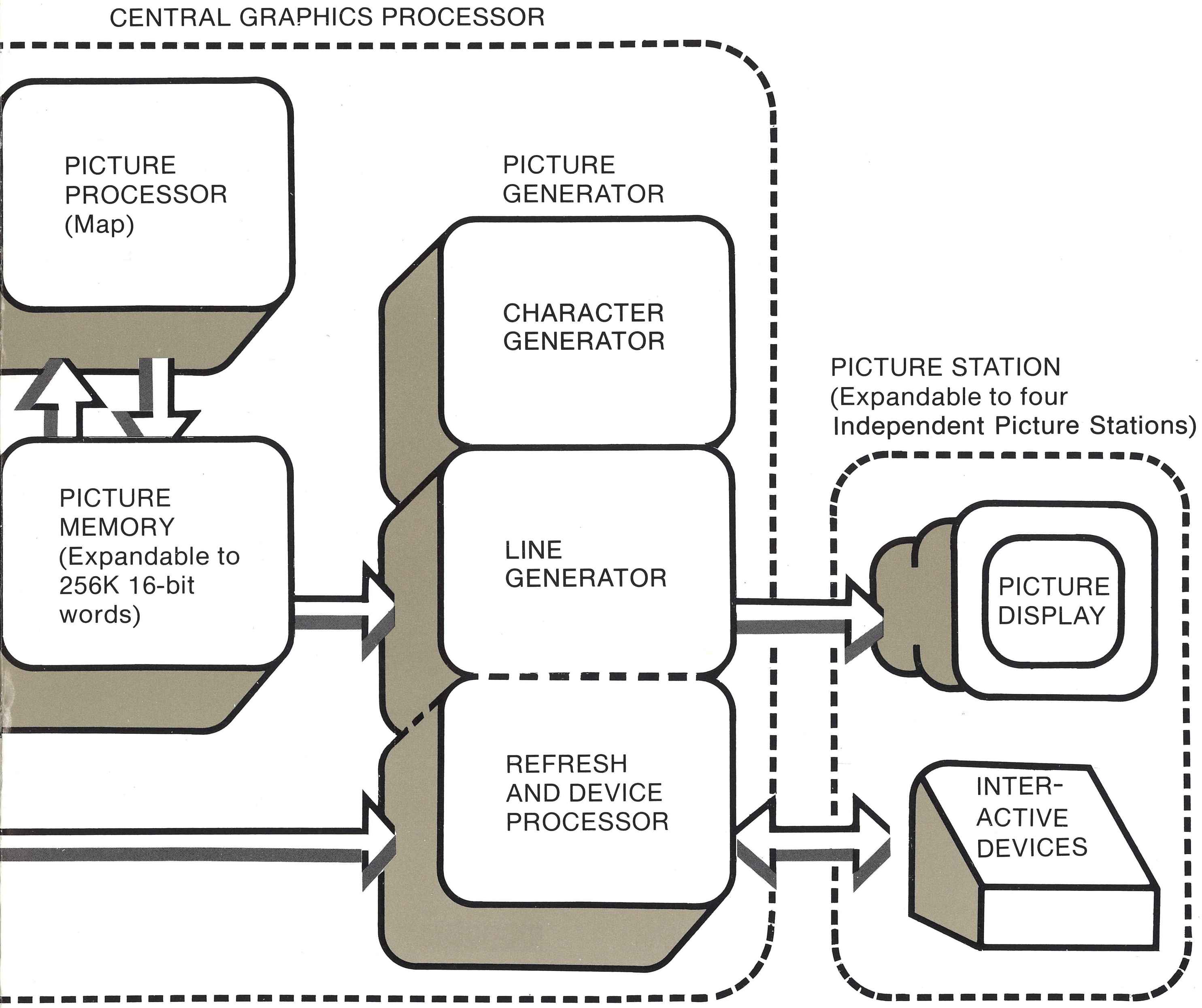


The Multi Picture System (MPS) is a general purpose, refresh, line drawing system designed to support several users simultaneously. The MPS interfaces to a mini-computer called a Picture Controller where the object description and applications programs reside. The Picture Controller can be a Digital Equipment Corporation PDP-11 or VAX 11/780.

The Multi Picture System is designed to support up to four Picture Stations from one Central Graphics Processor and allows as many as four Central Graphics Processors to interface to one Picture Controller. The application requirements for display complexity and user interaction dictate the optimum mix of Central Graphics Processors and Picture Stations.

The Central Graphics Processor (CGP) is the heart of the MPS. Here the Picture Processor performs the matrix arithmetic for clipping, perspective, 2-D or 3-D rotation, translation, depth cueing, and viewport mapping in real-time for dynamic graphics interaction. It provides the digital computation power necessary for imparting motion to pictures and overall system responsiveness to user commands.

The second segment of the CGP is the Picture Memory. Here the latest developments in Evans & Sutherland technology have been incorporated to expand the power of the Multi Picture System. By providing extended memory (up to 256K 16-bit words) Evans & Sutherland allows system users more memory space in which to


CENTRAL GRAPHICS PROCESSOR
PICTURE PROCESSOR (Map)
PICTURE MEMORY (Expandable to 256K 16-bit words)
PICTURE GENERATOR
CHARACTER GENERATOR
LINE GENERATOR
REFRESH AND DEVICE PROCESSOR
PICTURE STATION (Expandable to four Independent Picture Stations)
PICTURE DISPLAY
INTER-ACTIVE DEVICES

store both processed display files, fully double buffered, and the original data base. When the data base is stored in Picture Memory instead of host computer memory, the display program's address space is effectively increased, its operating system runs more efficiently and data base structuring is available.

The Picture Generator is the final module in the CGP. Here processed data is converted to line segments for the display, character codes are broken down into basic line segments, and interactive device polling is handled by the Refresh and Device Processor.

The Multi Picture System Graphics Software Package is provided with each system purchased. It consists of an RSX 11M or VMS driver and a library of Fortran callable subroutines which provides the user with access to the Central Graphics Processor's hardware features without an in-depth understanding of its details. This software package greatly simplifies the graphics programming task making the final application software development effort much shorter.

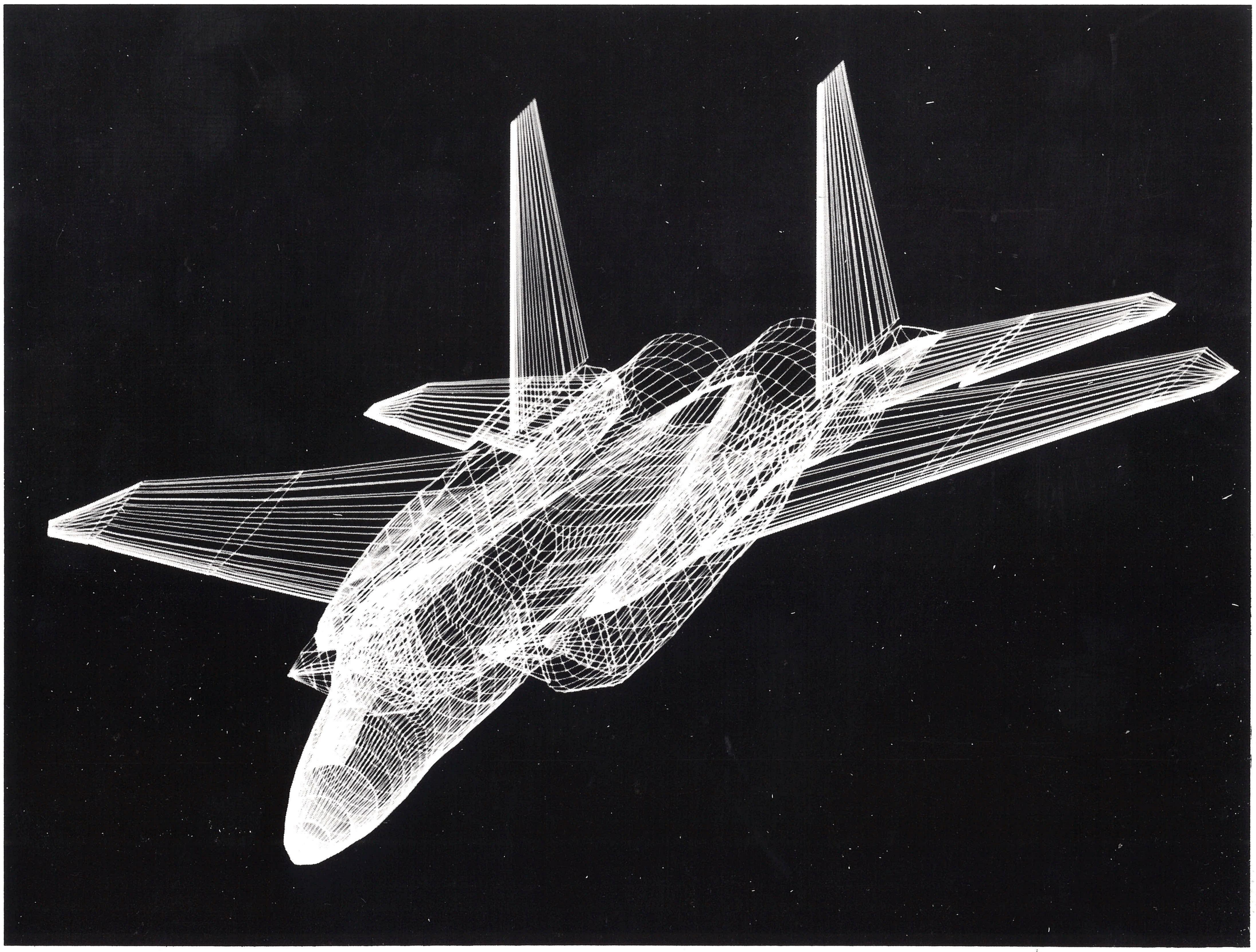
The user interface portion of the MPS is called a Picture Station and consists of a random stroke CRT, a work table, and a user selected group of interactive devices. Two Picture Station configurations are available. A light pen Picture Station has a table mounted CRT to position the display closer to the user. A data tablet Picture Station has a pedestal mounted CRT and a considerably larger work surface for interactive devices.

KEY DESIGN FEATURES

Sixteen-bit Coordinates—The Multi Picture System was designed so that its data base uses one full 16-bit word per coordinate. That is, a line endpoint is defined by a 16-bit X word, a 16-bit Y word, and possibly a 16-bit Z word. Coordinates may be defined anywhere in the range −32K to +32K in all three dimensions, yielding a very large "world" in which objects may appear. Through use of "homogeneous coordinates" the world can be made substantially larger.

Compounding of Transformations—Often the motion of an object in a dynamically moving scene cannot be described by a single simple linear transformation. For example, an object may be rotating while moving, or it may be a moving part of a larger object which is itself moving. The view of a moving object from a moving viewpoint is another example. In order to compute transformations representing such complex motions, it is necessary to concatenate the sequence of simple transformations representing the component simple motions. Hardware to perform these concatenations is included in the Multi Picture System, allowing them to be performed much more quickly and easily than would otherwise be possible.

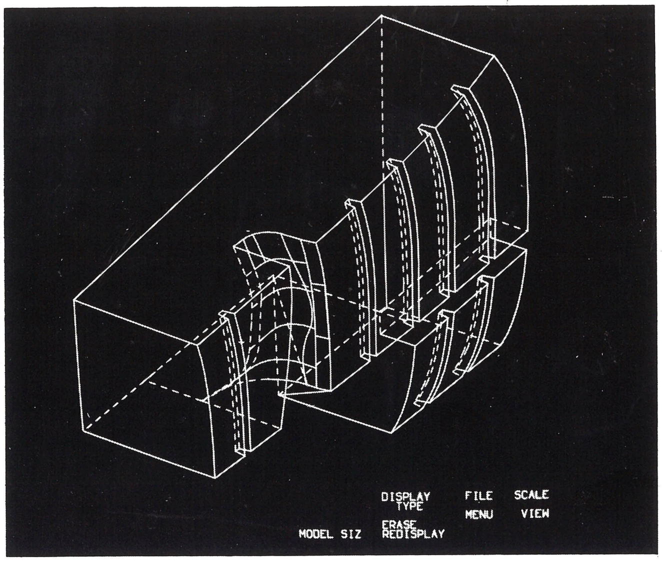
Clipping—Windowing is one of the most important functions of computer graphics. It allows the programmer to place a window at any location in his data base and to view on the screen only those portions of the data base that are within the window boundaries. "Clipping" is now generally regarded as the

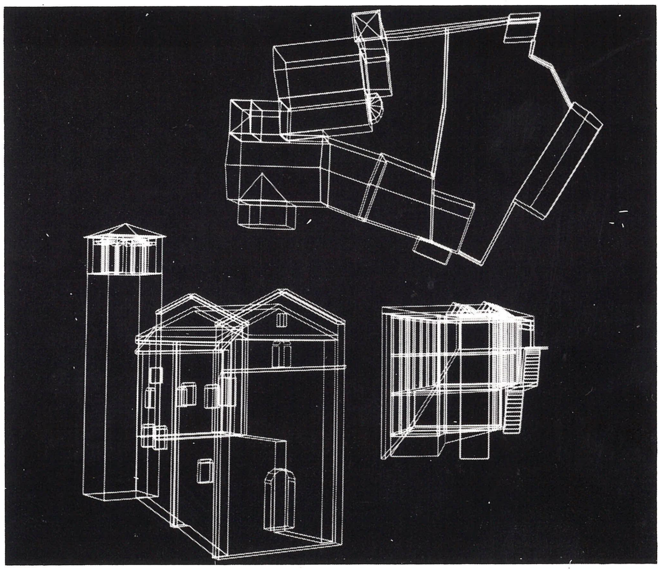


best method of performing windowing. The Multi Picture System implements clipping in hardware by examining each line or dot drawn to see whether it falls within a program-specified viewing window. Lines or portions of lines outside this window are eliminated at this point, prior to the line generation stage. In the Multi Picture System, lines are clipped to the four edges of the window and also, in 3D, to a front and a back plane as well. The positions of these edges and planes are under program control. A tactic which is sometimes very useful is to place the front and back planes very close together and move them back and forth as a pair through 3D objects, yielding pictures of cross sections on the screen.

Zooming—Often a scene is so large that when it is depicted in its entirety on a graphics system, details are obscured. When the details are to be shown, it becomes necessary to show only a portion of the scene but to show that portion in greatly increased scale. Abrupt changes in scale are visually unappealing and sometimes leave the viewer "lost" not knowing where in the scene he is looking. A far better alternative is to smoothly and rapidly vary the scale. This "zooming" feature is implemented in Multi Picture System by introducing small changes to the windowing boundaries each time a new frame is begun.

Viewports—The viewport mapping feature of the Multi Picture System separates the coordinate system of the data base from that of the display device, so that the programmer is free to think only in terms of the coordinate space of his data. The system performs viewport mapping as its final picture preparation step: lines in the window—having already been transformed, clipped, and put in perspective—are mapped linearly onto a program specified region of the display called a viewport. A given program may use several viewports for different views of an object, for viewing an object at different scales, or for displaying different objects. The multiple-viewport capability is a very convenient mechanism for the simultaneous display of several such subpictures, and in addition guarantees that they will not intrude upon one another.

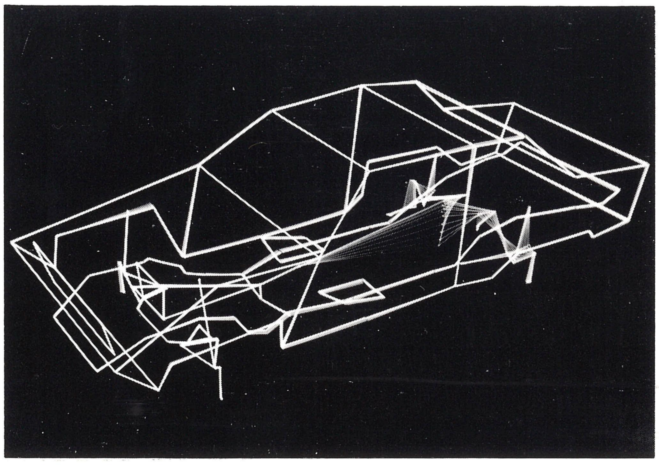




Independent Update and Refresh—A basic characteristic with refresh displays is that the picture must be redrawn very frequently—at least 30 and preferably 40 times per second—to avoid flicker (the unsightly effect seen when the picture visibly fades before being redrawn). Line generation speed imposes a limit on line and character capacities of course, but to make matters worse in many graphics system architectures, the line generator spends a lot of time sitting idle while coordinate data is being fetched or massaged. It is unnecessary and wasteful to update a picture every time it is refreshed; even in applications calling for the most stringent requirements for dynamic motion, an update rate of 15 times per second is usually adequate, and in other applications updating can be performed very infrequently. Sustaining a flicker-free picture, on the other hand, is universally necessary. The Multi Picture System allows both updating and refreshing to take place at their respective optimal rates, getting maximum mileage out of all system components. This was accomplished by placing a memory between the picture preparation stage and the picture generation stage. The picture generator can fetch new coordinates from this memory as soon as it is ready to accept them; meanwhile, a new frame is being computed and deposited elsewhere in the Picture Memory.

Line Quality—The Multi Picture System takes great care in assuring that lines are drawn at a constant rate, which creates lines of uniform intensity throughout their entire length. Also it assures that short lines and long lines have the same uniform brightness. The Multi Picture System has 64 different intensity levels which allow a very smooth implementation of depth-cueing when specified.

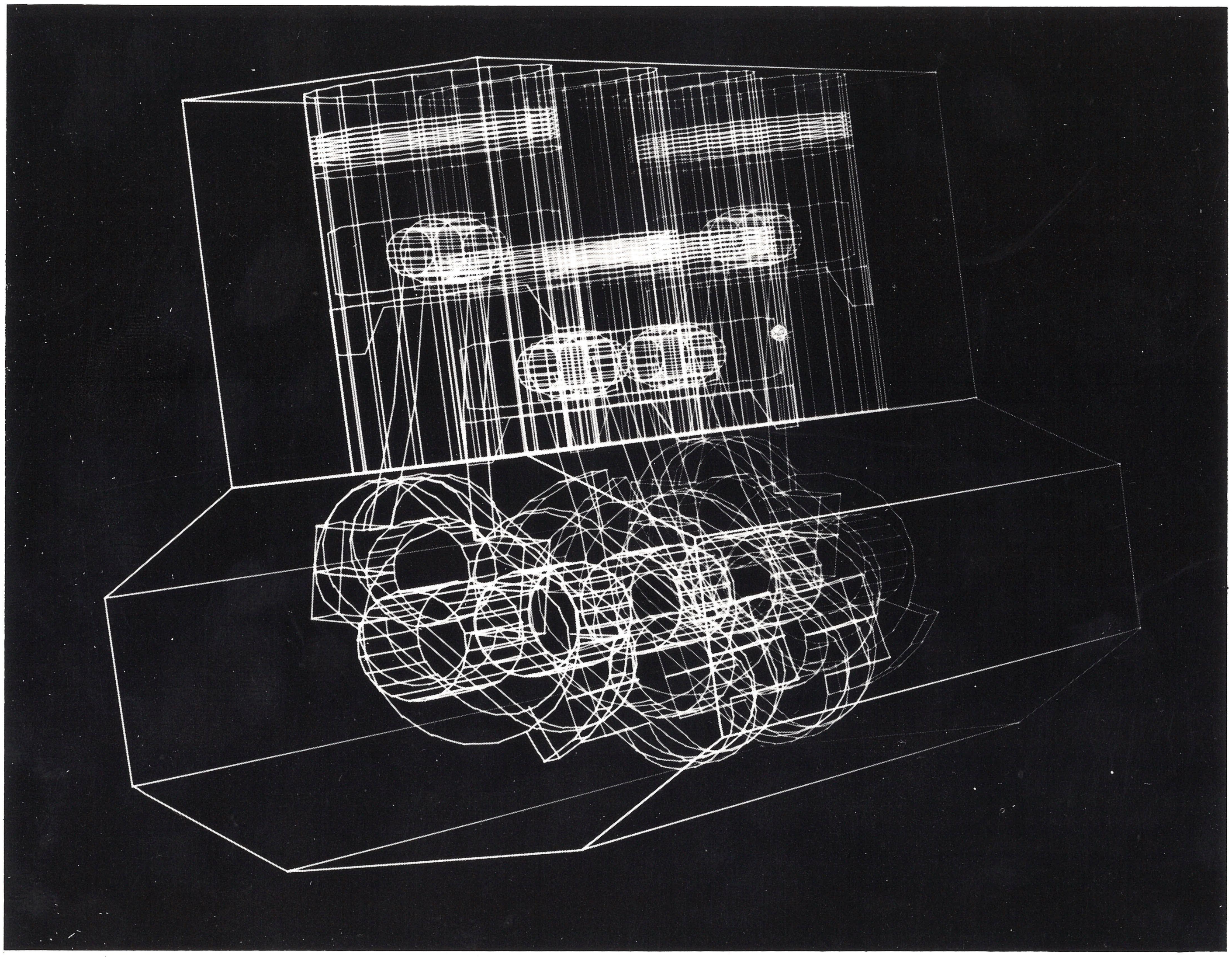
Standard Computer—The decision to use a single standard host computer in the Multi Picture System was very important because it permitted concentration on a single version of the system software, hardware interface, diagnostics, documentation, and other forms of support. An additional benefit is that application programs may be shared among users. The DEC PDP-11 and VAX family of computers was selected as the controller for the Multi Picture System for the following reasons: 1, many are installed in the field; 2, good hardware specifications; 3, good operating systems and software systems; 4, reliability of equipment; 5, good selection of peripherals available; 6, a world-wide sales and service organization; and 7, the UNIBUS concept makes it easy to interface devices like the Multi Picture System.



Graphics Software Package—Selecting a standard computer to control the Multi Picture System enabled a Standard Graphics Software Package to be written. This software package, whose routines are callable from either MACRO-11 assembly language or FORTRAN IV, isolates the hardware from the programmer. It allows the programmer to communicate his instructions to the Multi Picture System using parameters that are familiar to him.

Extended Memory—The extended memory feature expands the display list and system functions of this high performance, 3-D line drawing system. Prior to Extended Memory, the Multi Picture System had a 64K, 16-bit word refresh buffer limit. It can now be expanded to as much as 256K. The resulting memory space allows the user to store unprocessed display files as well as processed image segments, freeing him from address space limitations and improving update rate and system responsiveness. The most profound improvement occurs in multiple user applications, effectively reducing the cost per work station.

Segmentation—The Multi Picture System allows the user to break his picture presentation into small segments and alter only those segments that are changing. The other segments remain static and can be refreshed automatically. Segmentation results in a more efficient use of Picture Memory which in turn allows faster picture update rate with less burden on the host computer.



Perspective—Real world objects are seen in perspective, as are physical models of real world objects. Hence for a computer-based model to look realistic, it should be seen in perspective as well. Perspective gives the viewer a very striking feel for depth, especially when displaying moving objects, since portions of the objects close to the observer appear larger and move faster than portions farther away.

Multiple Work Stations—The Multi Picture System is a general purpose, high-performance, refresh, line drawing computer graphics system designed to support several users simultaneously, each interacting quickly and efficiently with pictures of 2-D or 3-D objects.

The Multi Picture System features a new high-level of cost effectiveness due to its expandability to multiple, independent work stations. This system capability coupled with the system's high-performance processing and display capabilities make it an excellent tool for a very diverse field of display projects.

MULTI PICTURE SYSTEM OPTIONS

Data Tablet—The standard data tablet of the Multi Picture System is the Summagraphic ID Series tablet assembly including an 11″ x 11″ active area tablet surface, a stylus, a controller and an interface to the Picture Data Bus. The data tablet option is used as an interactive pointing and positioning device and normally is used to control a cursor display on the CRT.

Light Pen—The light pen option is an interactive device normally used for identifying (pointing) and positioning data items on the display. It communicates with the Picture Data Bus through an interface that supports two light pen units. The light pen detects items on the display by a photocell in the pen that "sees" the line pointed to on the display.

Control Dials—The analog control dials are available as interactive data input devices which are interfaced to the Picture Data Bus by the Evans & Sutherland analog-to-digital converter module. This module has sixteen channels and can support one or two control dial units, each containing eight continuous-turn control dials.

Joystick—The joystick is available as an interactive data input device. It interfaces to the Picture Data Bus through three channels of the analog-to-digital converter module, the same module used by the control dials option. This option is a three-axis joystick where two axes are controlled by movement of the stick forward or backward and side to side and the third axis is controlled by rotating a knob at the top of the stick. All axes have spring-return to zero.

Function Switches & Lights—The function switches and lights are available as interactive data input and data display devices for the Multi Picture System. Each set of function switches and lights has sixteen white toggle switches and sixteen white lights and is interfaced to the Picture Data Bus.

Lighted Function Buttons—Each set of lighted function buttons has thirty-two momentary push button switches arranged in an array of one row of four buttons followed by four rows of six buttons followed by one row of four buttons. These buttons may also be lighted under program control. Each lighted function button interface supports two lighted function button units.

Alphanumeric Keyboard—The alphanumeric keyboard generates an interrupt request to the Picture Controller whenever a key is struck, whereupon the user program may read and act upon the code for the key struck. It has 63 keys with shift, lock and control keys, allowing a total of 128 character codes to be entered. The keyboard has an option called the Remote Terminal Interface that interfaces to the Picture Controller and allows the keyboard and display to perform as a terminal to the Picture Controller.

Hardcopy Device—Evans & Sutherland can provide electrostatic printer/plotters in a variety of sizes for a customer's hardcopy requirements.

EVANS & SUTHERLAND presents...

MULTI PICTURE SYSTEM WITH EXTENDED MEMORY

EVANS & SUTHERLAND

EVANS & SUTHERLAND
580 ARAPEEN DRIVE, SALT LAKE CITY, UTAH 84108, (801) 582-5847

EVANS & SUTHERLAND

MULTI PICTURE SYSTEM BRIEF SPECIFICATIONS

CENTRAL GRAPHICS PROCESSOR

Picture Processor

High-speed, digital processing

Transformations
- Translation in any direction
- Rotation about any axis
- Scale with respect to any dimension
- Mirror Images about a plane
- Transformations expressed as a 4 x 4 matrix

Compound Transformations

Clipping

Perspective

Viewport

Zooming

Hit Test

Picture Memory

Separation of display refresh and dynamic update

Dual Port Memory

16-bit word size

Memory size—32K through 256K words in 32K word increments

Refresh and Device Processor

Refresh rate
- 60Hz, 40Hz, 30Hz, etc. as necessary using 60Hz power
- 50Hz, 33Hz, 25Hz, etc. as necessary using 50Hz power

Buffer modes—double buffer & segmented buffer

Handles interactive device I/O

Character Generator

128 ASCII character codes

256 user programmable codes

Character sizes from .03″ to .74″ standard

64 user programmable sizes and orientations

No character wrap around

Line Generator

Line Modes
- Seven line types
- Dots
- Blinking
- Continuous texture modes for dashed lines

Display select

64 levels of constant intensity

Depth-cueing

PICTURE STATIONS (up to four)

Picture Display (monochrome)

Calligraphic (random stroke)

4096 x 4096 x 64 addressable locations

21″ rectangular screen

16″ x 13″ viewing area

10″ x 10″ quality viewing area

P4 phosphor standard

0.020″ spotsize and endpoint match

Picture Display (color)

Calligraphic (random stroke)

4096 x 4096 x 64 addressable locations

25″ rectangular screen

64 hues covering entire spectrum

8 saturations of each hue

Interactive Devices

Data Tablet

Light Pen

Alphanumeric Keyboard

Control Dials

Joystick

Lighted Function Buttons

Function Switches & Lights

EVANS & SUTHERLAND

SPECIFICATIONS FOR THE EVANS & SUTHERLAND COLOR DISPLAY

CRT

RGB, shadow mask, .0145″ triad spacing.

26 inch (25V) diagonal rectangular with bonded implosion protection. Magnetic deflection, magnetic convergence, electrostatic focus, 90° deflection angle.

Area for which these specifications apply is the center 13″ by 13″ area of the CRT. All specifications are measured after a 30 minute uninterrupted power up period.

COLOR

Programmable selection of 64 Hue and 7 Saturation values.

PHOSPHOR PROTECTION

Provided during power up and power down of display. No Dynamic protection is provided.

PHYSICAL

Maximum Outside Dimensions of Work Station Including Display Head—
- 27.00″ Wide
- 51.00″ High
- 53.00″ Deep
- 29.00″ Work Depth
- Weight 450 lbs.

BRIGHTNESS

4 FL, with a 13″ x 13″ white raster of 512 lines drawn at 40 Hz.

GEOMETRIC DISTORTION

The greater of ±3% deflection or .050 inches.

ORTHOGONALITY

Within ±.05 degrees

JITTER

±.012 inches maximum

CONVERGENCE

Adjustable within ±.010 inches within a circle of 6″ radius

Adjustable within ±.035 inches within the 13″ x 13″ area

CONVERGENCE DRIFT

Maximum ±.010 inches in a circle of 6″ radius over an eight hour continuous period of operation

SPOT SIZE (LINE WIDTH)

Adjustable from .015 to .040 inches
Optimum performance at .025 inches

END POINT MATCH

.030″

LINE DRAWING TIME T (IN USEC) for line of Length L (in inches):

For $L \leq .16$, $T = 2.5$
For $.16 < L \leq .22$, $T = 1.6 + 5.18 * L$
For $L > .22$, $T = 2.1 + 2.6 * L$

MOVE TIME T (IN USEC) for move of distance M (in inches):

For $M \leq .70$, $T = 2.0$
For $M > .70$, $T = 1.1 + 1.30 * M$

DOT TIME T (IN USEC) to move Distance D (in inches) and then draw a dot:

For $D \leq .39$, $T = 1.8$
For $D > .39$, $T = 1.30 + 1.30 * D$

POWER AND ENVIRONMENT

Primary Power:
240 V ±10% a.c.
50 to 60 Hz Single Phase
21 amps max.

208 V (120 V Two Phase)
50 to 60 Hz
20 amps max.

Power Consumption:
2.5 KW

Heat Dissipation:
8533 BTU/HR

Operating Temperature:
65°F to 80°F
18°C to 27°C

Relative Humidity:
20% to 80%

Plug (supplied) Hubbel 2621 mates with:
Connector Body Hubbel 2623 (Cord Mount Receptacle)
Wall Mount Hubbell 2620 (Single Receptacle)

Cable Length:
25 ft. standard from Processor to display head

EVANS & SUTHERLAND

EXTENDED MEMORY

The MULTI PICTURE SYSTEM, Evans & Sutherland's fourth generation, high-performance, 3-D line drawing system has now been enhanced by a four-fold increase in Picture Memory.

Maximum Picture Memory has been increased from 64K 16-bit words to 256K 16-bit words. This increase in Picture Memory extends the Multi Picture System's capabilities, optimizes performance and insures greater reliability.

Now, with Extended Memory, a user may store a complete graphics program consisting of a data base and instructions on how to view and interpret the data.

Extended Memory is also less expensive for most customers. The minimum configuration now contains 32K Picture Memory which costs the same as a 32K Multi Picture System. But, add-on memory costs half what it used to per word.

Once again, with Evans & Sutherland's proven hardware, powerful software, thorough diagnostics and excellent maintenance support, the Multi Picture System with Extended Memory is the right tool for your computer graphics needs.

EXTENDED MEMORY FEATURES

Increased Total Memory Capacity

Expandable from 32K 16-bit words to 256K words in 32K word increments

Increased Reliability

Single-bit errors automatically detected and corrected; double-bit errors detected

Reduced Cost

Add-on Picture Memory cost per word is one-half the cost of previous memory

Upward-compatible Software

Existing RSX-11M and VMS task images will continue to function without modification

Increased Refresh Memory Capacity

Each user may have up to approximately 64K words of Picture Memory for refresh

Increased Untransformed Data Memory Capacity

Each user may have untransformed data in one or more "contexts" of up to approximately 64K words per context

Fully-Supported Untransformed Display

Lists (UDL) User Software Package for RSX-11M and VMS

Field Upgrade

Existing Multi Picture Systems can be upgraded to Extended Memory

EXTENDED PICTURE MEMORY SPECIFICATIONS

EXTENDED PICTURE MEMORY	
	General purpose storage medium for processed and unprocessed data. A passive only device.
Memory Type	Dual Port 16 pin 16K x dynamic MOS IC's
Word Size	22 bits internal, 16 data bits, 6 error detection/correction bits 16 bits external
Memory Size	32K through 256K words in 32K word increments
Memory Management	Mapping Registers for Active Devices 256 word pages, 255 pages addressable without changing mapping register contents
Error Detection/Correction	Single bit, detected and corrected Double bit, detected
Maximum Throughput	1.33 M wps, 1 Active device 2.22 M wps, 2 Active devices (1.11 M wps each) 2.50 M wps, 3 Active devices (.83 M wps each)
Memory Uses	User Storage Untransformed data file Transformed display file Transformed data file
Display File Content	Dots and line endpoint data for use by the Picture Generator. One dot or line endpoint entry requires 2 words of memory, 12 bits for x, 12 bits for y, 6 bits for intensity, and 2 bits for command. Packed character codes for use by the Character Generator. One entry requires 2 words of memory and contains up to 4 character codes. Control information used to direct the operation of the Picture Generator. Each entry requires 2 words of memory.
Display File Size	Up to 8K entries for each 16K memory module.